PATENT SPECIFICATION

DRAWINGS ATTACHED

844,819

Date of Application and filing Complete Specification June 17, 1958.

No. 19299/58.

Application made in United States of America on June 20, 1957.

Complete Specification Published August 17, 1960.

Index at Acceptance:—Classes 2(5), R27K3(A:M6:M7); and 95, B4(B:C).
International Classification:—B05. C08g.

COMPLETE SPECIFICATION

Coated Articles and Method of Production Thereof

We, THE POLYMER CORPORATION, a Corporation of Pennsylvania, United States of America, of Reading, Pennsylvania, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to improved fiberglass-reinforced plastic articles and to methods of making such articles, and more particularly to such articles having improved surface characteristics.

Fiberglass-reinforced plastics are well-known, and they have been employed extensively in the commercial molding of plastics articles for more than ten years. In general, such articles are made by embedding flexible strands of fibrous glass in various plastics, and molding the resultant composite mass to produce the desired configuration. The plastics employed may be either thermoplastic or thermosetting resinous compounds. Thermosetting plastics, such as the phenolics, melamines, epoxies and silicones have proved useful, and thermoplastic resins, such as polyethylene, polystyrene, polyvinyl chloride and the polyesters, may also be selected advantageously. The glass strands used can be in a wide variety of forms, including unidirectional or bidirectional fabrics, mats, yarns, continuous strands or chopped lengths of strands. Random mat, roving, or chopped strands are often chosen when minimum cost is desired. Various methods of molding the composite fiberglass-reinforced plastics may be employed, including compression, injection and transfer molding methods, and various laminating procedures are suitable.

The reinforcement provided by the embedded glass fibers produces increased mechanical strength, stiffness, impact resistance and dimensional stability, nearly in proportion to the relative volume of glass present in the composite fiberglass plastic articles. Such articles possess an unusually high strength to weight ratio, and they are capable of bearing tremendous loads. They are particularly useful in the molding of large shapes, and in recent years they have been employed to a limited extent in the production of special automobile bodies. Since fiberglass-reinforced plastics possess excellent electrical and thermal insulating properties in addition to their outstanding structural characteristics, their field of potential utility appears to be very extensive.

The expected importance of fiberglass reinforced plastics which was predicted during their early stages of development ten years ago has failed to materialize today. Although well-defined markets have been developed for specialized uses of such plastics, the scope of their employment is considerably less extensive than was forecast during their development. One of the principal reasons for the lack of large-scale usage of fiberglass-reinforced plastic articles is the poor surface finish of such articles. The embedded glass strands tend to protrude from the surface of the molded articles, thereby making the surface appear dull and flat. To the touch such surfaces feel rough and unpleasant. This effect renders the articles unacceptable for many purposes where smooth, glossy surfaces are desired, such as in kitchen appliances. Attempts have been made to hide the pattern of the protruding glass strands by employing embedded surface mats composed of monofilament strands having incorporated therein a binder resin compatible with the molding resin. In some cases the incorporation of fillers in the molding resin has produced a slight inprovement in the surface finish by reduction of the cure shrinkage of the resin. Nevertheless, acceptably smooth surfaces have not been obtained by any of the methods known heretofore.

Another important reason for the failure of

fiberglass-reinforced plastics to achieve the extensive market originally anticipated, is the difficulties encountered in applying paint and other surface finishes thereto. The methods employed heretofore have required laborious surface preparation, and the finishes produced have often failed under extreme humidity conditions. The production methods employed have been expensive, slow, and subject to an abnormally high percentage of rejects. Consequently, a great demand has existed for truly smooth-surfaced fiberglass-reinforced plastic articles, and for efficient methods of applying to such articles surface finishes of sufficient thickness to hide the protruding glass strands embedded therein.

An object of the present invention is to provide smooth-surfaced finishes on fiberglass-reinforced plastic articles.

Another object of the invention is to provide new and improved methods for economically and efficiently applying surface finishes to fiberglass-reinforced plastic articles.

Still another object of the invention is to provide fiberglass-reinforced plastic articles with smooth-surfaced finishes of sufficient thickness to hide the protruding glass strands embedded therein, and to provide methods of producing such finishes.

Other objects and advantages of the invention will become apparent from the following detailed description of specific embodiments thereof.

In accordance with the present invention, a melting or fusion of pulverulent coating materials is employed to apply relatively thick coatings of compatible coating materials to the surfaces of fiberglass-reinforced plastic articles. This fusion coating is preferably applied by the formation of a fluidized bed of a finely divided, free-flowing powdered coating material by passing an ascending current of gas through a laterally confined mass of such a coating material. The molded fiberglass-reinforced articles to be coated are preheated to a temperature above the sintering point of the pulverulent coating material, and then the heated articles are dipped into the fluidized bed and held immersed therein until they have become coated by fusion of the coating material particles thereon. Finally, the coated articles are removed from the bed and cooled to normal room temperature to solidify the coating. In this manner smooth-surfaced coatings of sufficient thickness to hide the protruding glass strands embedded in fiberglass-reinforced articles may be produced economically and efficiently.

A complete understanding of the invention may be obtained from the following detailed description of methods and products embodying the invention, when read in conjunction with the appended drawing, in which the single figure is a side elevation view, partially in section, of a preferred form of apparatus designed for employment in performing methods embodying the invention to produce articles embodying the invention.

Referring in more detail to the drawing, there is shown a container 10 which may be constructed of a convenient structural material, such as steel, for example, and which has an open top as indicated at 12. The container 10 is divided into an upper chamber 14, in which the pulverulent coating material is confined, and a pressure chamber 16, by a gas-pervious partition 18. This partition, which should be pervious to the gas used but impervious to the particles of coating material, may preferably take the form of a porous ceramic plate, although other similar structures may be advantageously used. A porous plate structure which is preferred is composed of "Alundum" (Registered Trade Mark) which is a refractory material composed of crystalline aluminium oxide in granular form. Whether composed of this or other materials, the porous plate preferably has a gas permeability which may be defined as that which will permit the passage of from one to fifteen cubic feet of air at 70°F. and 25 percent relative humidity through an area of one square foot and a plate thickness of one inch at a pressure differential equivalent to two inches of water in a period of one minute. The average pore diameter of the porous plate should preferably be in a range from 0.003 to 0.004 of an inch or less.

The container 10 is provided with a gas inlet opening 20 which is adapted for connection through a shut-off valve 21 to a suitable source of gas under pressure in order to pressurize the pressure chamber 16. The source of gas under pressure is not shown, since it may consist of any conventional source, such as a steel "bottle" of precompressed gas, or, if air is to be used, a conventional air compressor and accumulation tank may be used. When air is to be used, it is also possible to attach an air blower or pump directly to the inlet connection 20.

In the practice of the process of this invention, a quantity of very finely divided coating material is placed in the upper chamber 14 of the container 10, and gas under pressure is admitted through the connection 20 into the pressure chamber 16. The gas from the lower chamber 16 passes through the gas-pervious partition 18 and flows upwardly in many finely divided streams, or in what might be characterized as a parallel upward flow from the entire upper surface of the partition 18, through the finely divided or pulverulent coating material. This upwardly moving gas causes some of the particles to be raised and separated from the others in what has been called a fluidization effect or a rarefication of the coating material. In this state, the coating material has the feeling and appear-

ance of a liquid, although it is actually simply a dry mixture of gas and solid particles. The rarefication and fluidization of the coating material is such that solid objects may be immersed within the coating material so as to be completely surrounded thereby, just as such an article might be dipped into a liquid.

In applying the coating, the fiberglass-reinforced article to be coated is heated to a temperature which is above the melting temperature of the pulverulent coating material, and then the article is dipped into the fluidized or rarefied coating material, and preferably moved to and fro so that the particles of coating material which come into immediate contact with the surface of the article adhere thereto and are melted thereon. When the article is subsequently cooled, the solidified coating material forms a continuous coating on the article.

Any gas which is reasonably inert at the temperatures and with the materials employed may be used as the gaseous medium for fluidizing the coating material. Air is usually satisfactory and is preferred for reasons of economy; however, in order to avoid oxidation or degradation, it is sometimes preferable to use nitrogen or some other non-oxidising gas. The pressure of the gas may vary greatly, depending on the particular shape and dimensions of the treating tank as well as on the particular type of coating material used. The pressure of the gas, however, should not exceed the point where the upper level of the fluidized bed of coating material rises above the sides of the container or where an appreciable dust cloud of the coating material is formed above the container.

The consumption of the gas will generally be from about 70 to about 700 cubic feet per hour. It will be understood, of course, that the rate of gas flow is very dependent upon the size and configuration and design of the apparatus which is used for the practice of the process.

Preheating of the fiberglass-reinforced article to be coated may be performed in any suitable oven, or the like. The preheating temperature of at least the surface to be coated should be above the melting or sintering temperature of the pulverulent coating material. When the coating material is polyethylene, for example, the preheating temperature should be above 250°F. Of course, in preheating molded or laminated fiberglass-reinforced plastic articles to be coated, care must be taken to avoid long exposure to temperatures exceeding the softening temperature of the plastic of which such articles are composed, lest the articles be damaged by distortion. Consequently, in selecting the coating material it is necessary to choose materials which melt at a temperature at least slightly below the softening temperature of the plastic of which the fiberglass-reinforced article is composed, and which are compatible therewith to secure good adhesion of the coating. In order to compensate for inability to heat the article to be coated to what would usually be a sufficiently elevated temperature, as in the case of certain molded fiberglass-reinforced plastic articles having a low melting molding resin incorporated therein, the entire fluidized bed of coating material may be heated to a temperature which approaches but does not exceed the sintering point of the pulverulent coating material. This may be accomplished by heating the gas employed to fluidize the bed, or by providing a heated jacket surrounding the container in which the bed of coating material is confined.

Since in most cases primary reliance is placed upon the heat stored within the preheated articles to fuse the coating material in forming coatings thereon, it is possible in many instances to form coatings successfully when the fluidized bed is maintained at normal room temperature. However, it is advisable to maintain the fluidized bed at a temperature elevated sufficiently to prevent the accumulation of moisture in the bed, and this may be accomplished conveniently by slightly raising the temperature of the gas employed to fluidize the bed. Of course, care should always be taken to maintain the temperature of the gas and the bed below the melting point of the coating material.

Only a short period of immersion in the fluidized bed of coating material is necessary to obtain an adequate coating on the articles being coated. An immersion time of less than fifty seconds is usually adequate, and preferably the immersion time is less than thirty seconds.

A postheating operation may sometimes be required to coalesce completely and smoothen the coatings formed on the articles. When the coated articles are first withdrawn from the fluidized bed of coating material, the coatings may appear rough and covered with clinging particles of the coating material. The heat stored in articles having a sufficient heat-storage capacity will soon melt these clinging particles. However, for articles having a small heat-storage capacity and articles which cannot be heated to elevated temperatures, it may be necessary to resort to a postheating operation to smoothen the coatings. Usually a blast of air is first employed after withdrawal from the fluidized bed to blow off excess clinging particles of the coating material. Any suitable oven or the like may be used for postheating the coated articles. Some plastics compounds have such a high ignition temperature that a flame from a gas torch may be played directly over the surface of the coating to smoothen it.

As the final step in the process the coated

articles are cooled, and this is ordinarily done slowly by allowing the articles to stand in atmospheric air or a non-oxidising atmosphere maintained at normal room temperature. For some coating materials, it may be preferable to rapidly cool the coatings, which may be done by quenching them in cool water.

Many different plastics coating materials may be employed in practising the invention. Because of the problems outlined above in selecting a coating material which does not require a preheating temperature which is excessive, in the practice of the present invention low-melting thermosetting or thermoplastic resins are preferred. Included among the most useful thermosetting resins may be mentioned the epoxies, the silicones, the epoxy-phenolics, and mixtures and modifications thereof. The lower-melting thermoplastics are preferred such as plasticized cellulose acetate butyrate and ethyl cellulose, for instance. However, higher-melting thermmoplastics such as polyethylene of the polyamides which are commonly commercially known as "nylons" can be used occasionally when the articles to be coated are capable of withstanding higher preheat temperatures. The above classes of resins are mentioned, of course, only as representative examples as a tremendous variety of materials can be used in accordance with the present invention.

It is contemplated that any of the plastics coating materials employed in this invention may have suitable fillers, plasticizers, and pigments incorporated therein. Whatever additional ingredients may be employed, it is essential for the coating material to be in a substantially dry, finely divided, free-flowing powdered form. Granular particles ranging in size from about 0.001 to 0.024 inches in diameter are most suitable. In contrast to the substantially dry, free-flowing powdered coating materials employed in the present invention, the coating materials customarily employed heretofore in attempting to apply plastics coatings were generally solutions and liquid dispersions, which required expensive special solvents and dispersing agents, as well as complicated drying and solvent recovery apparatus, and they produced inadequately thin coatings.

Methods embodying the invention are capable of economically and rapidly producing coatings of four thousandths of an inch or greater in thickness in a single coating operation. It has been found that a coating only one thousandth of an inch in thickness is sometimes adequate to hide most of the protruding glass strands embedded in fiberglass-reinforced plastic articles, and provide a desirably smooth-surfaced, glossy finish thereon. However, it is preferred to form coatings at least four thousandths of an inch in thickness to assure complete coverage, and coatings more than twenty thousandths of an inch thick have been formed successfully. In prior attempts to produce coatings of sufficient thickness to accomplish the present objectives, it was necessary to apply a large number of separate coating layers in succession. Furthermore, the prior art approaches often required laborious surface preparation of the articles to be coated, and the applied coatings frequently failed under extreme humidity conditions. According to the present invention, adequately thick coatings are applied in what is essentially a single-step coating operation, even though a primer coating may be desirable in some instances, and smooth-surfaced, glossy finishes are obtained thereby.

Coated fiberglass-reinforced plastic articles embodying the invention greatly extend the potential field of utility of such reinforced articles. The smooth, glossy surfaces of coated articles embodying the invention at last renders such articles acceptable for utilization in the construction of kitchen appliances, such as refrigerators and washing machines, and for various office machines, such as typewriters and tabulating machines. Moreover, by proper selection of the plastic coating materials, and the fillers and pigments which may be incorporated therein, a wide range of physical properties, colors, and patterns may be achieved for the finishes, thereby satisfying a broad range of service conditions.

The following examples are intended to exemplify the process and product of this invention, but it is understood that the scope of the invention is not necessarily limited thereby to the method steps or materials set forth therein.

Example 1

A phenolic fiberglass-filled circular cross section tube of about 3 feet in length and 1/4 inch in diameter and having a wall thickness of approximately 1/32 of an inch is filled with small steel shot and the ends are closed with aluminum foil which may be stuffed into the ends or fastened over the ends with a suitable high-temperature adhesive. The tube is then placed in a 650°F. oven for about 2 minutes. The tube is then removed and immersed for about 10 seconds in a fluidized bed of a pulverulent red pigmented plasticized cellulose acetate butyrate formulation for a period of about 10 seconds. The tube is then removed from the fluidized bed and it is observed that the pulverulent material has fused to form a coating thereon. The tube is then placed in a 500°F. oven for about one minute to completely fuse and smooth the coating thereon. The tube is then removed and permitted to cool gradually in air. The resultant coating is about ten thousandths of an inch in thickness, is very smooth and

glossy, and has an excellent appearance. There is no sign of protruding glass fibers at the surface of the coating.

Example 2

A polyester fiberglass coil form on which a copper coil has already been wound is preheated for about 7 minutes in a 325°F. oven. This article is then removed from the oven and immersed in a fluidized bed of an unpigmented epoxy formulation which has been partly cured. This material is in the form of substantially dry, solid, pulverulent particles having a particle size such that all of the particles are capable of passing through a 70 mesh screen. This epoxy material is a partially reacted mixture of a commercially available liquid epoxy polymer and a commercially available solid epoxy polymer prepared by mixing fifty parts by weight of each of these epoxies while heated so that the solid epoxy is in a melted condition. While heated, fifteen parts by weight of a modified phenylene diamine curing agent is added to the mixture and the mixture is then permitted to cool and solidify gradually to room temperature, after which it is ground to the 70 mesh particle size.

After immersion for 3 seconds, the article is removed from the fluidized bed and again placed in a 325°F. oven for about 30 seconds. The part is again immersed for about 3 seconds in the fluidized bed. This process is repeated for a total of four 3-second immersions and the article is then placed in the 325°F. oven for a period of 15 minutes in order to complete the cure and hardening of the epoxy material.

The result is a hard, tough, continuous coating of approximately twenty-five thousandths of an inch in thickness which completely covers all protruding glass fibers. The coating completely covers and encapsulates the polyester fiberglass coil form and the coils of copper wire which are wound upon the form.

Example 3

A one-piece chair body which is comprised of approximately 40 percent fiberglass and the remainder being a polyester resin filled with magnesium silicate and having an average thickness of approximately one-eighth of an inch is heated in a 550°F. oven for about 5 minutes and is then dipped in a fluidized bed of pulverulent coating material for a period of about 4 seconds. The coating material is a red pigmented plasticized cellulose acetate butyrate formulation having a particle size fine enough to pass through a standard 40 mesh screen. After immersion, the chair body is placed in a 500°F. oven for about 2 minutes in order to smooth out and completely fuse the coating thereon. The resultant coating is about eight thousandths of an inch in thickness, has an excellent appearance and completely covers the fiberglass filaments previously visible in the surface of the chair body.

Example 4

A chair body identical to that described above and having an average thickness of approximately 1/8 of an inch is heated in an oven at about 450°F. for about 7 minutes. It is then immersed in a fluidized bed of pulverulent epoxy coating material having a size of less than a standard mesh of 40. This epoxy resin material is a hot blended mixture of 100 parts of an epoxy polymer having a specific gravity of 1.15, a curing temperature of 400°F.; and 20 parts of a polyamide having a specific gravity of 0.98 and a melting point from 271°F. to 239°F., and 8 parts of a dicyandiamide catalyst.

The chair body is immersed in the fluidized bed for about 4 seconds after which it is removed and placed in a 250°F. oven for 17 hours to completely fuse and smooth the coating and to cause it to cure into a hard finish. The resultant coating is about .010 of an inch in thickness and completely hides the fiberglass filaments previously apparent in the surface of the molded article.

WHAT WE CLAIM IS :

1. A method of forming smooth-surfaced finishes on fiberglass-reinforced plastic articles which normally have rough surfaces caused by protruding glass strands, comprising the steps of forming a fluidized bed of a finely divided, free-flowing, powdered, compatible plastic coating material, immersing the fiberglass-reinforced article to be coated in the fluidized bed while said article is heated to a temperature above the sintering point of the coating material, and holding the article immersed in the bed until it becomes coated by fusion of the coating material particles thereon and the coating is sufficiently thick to hide the protruding glass strands.

2. A method of forming smooth-surfaced finishes on fiberglass-reinforced plastic articles which normally have rough surfaces caused by protruding glass strands, comprising the steps of forming a fluidized bed of a finely divided, free-flowing, powdered, compatible plastic coating material by passing an ascending current of gas through a laterally confined mass of said coating material, heating a fiberglass-reinforced article to be coated to a temperature above the sintering point of the coating material, immersing the article in the fluidized bed, holding the article immersed in the bed until it becomes coated by fusion of the coating material particles thereon and the coating is sufficiently thick to hide the protruding glass strands, withdrawing the article from the bed, and then cooling the article to solidify the coating.

3. A method of forming smooth-surfaced finishes on fiberglass-reinforced plastic articles which normally have rough surfaces

caused by protruding glass strands, comprising the steps of forming a fluidized bed of a finely divided, free-flowing, powdered, compatible plastic coating material by passing an ascending current of gas through a laterally confined mass of said coating material, heating the gas and the entire fluidized bed to a temperature approaching but not exceeding the sintering point of the powdered coating material, heating a fiberglass-reinforced article to be coated to a temperature above the sintering point of the coating material, immersing the heated article in the heated bed, holding the article immersed in the bed until it becomes coated by fusion of the coating material particles thereon and the coating achieves a thickness of at least four thousandths of an inch, withdrawing the article from the bed, and then cooling the article to solidify the coating.

4. The method defined by claim 1 wherein the coated article is subsequently subjected to a postheating treatment at a temperature sufficient to coalesce and smoothen the coating thereon.

5. The method defined by claim 4 in which the coating material is a thermosetting plastic and the postheating is continued at a temperature and for a time sufficient to cause the coating to become thermoset.

6. An improved molded plastic article having an inner portion which contains a substantial proportion of glass fibers for mechanical reinforcement and an outer surface portion at least four thousandths of an inch in thickness which is substantially free of said glass fibers, said outer surface portion having been applied by the method claimed in any of claims 1 to 5.

7. An improved plastic article comprising an inner portion and an outer surface portion, said outer surface portion having a thickness of at least four thousandths of an inch and said inner portion containing a substantial proportion of glass fibers for mechanical reinforcement, said glass fibers being substantially confined to said inner portion, said outer surface portion having been applied by the method claimed in any of claims 1 to 5.

For the Applicants.

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Printed by Swindon Press Ltd.
Published by The Patent Office, 25, Southampton Buildings, London, W.C.2, from which copies may be obtained.

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